BLOOD COMPONENT THERAPY IN OPEN HEART SURGERY

Essay

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LIST OF ABBREVIATIONS

2, 3-DPG	2, 3-diphosphoglycerate
5HT	Serotonin
ACT	Activated Clotting Time
ADP	Adenosine diphosphate
ANH	Acute Normovolaemic Haemodilution
aPTT	Activated Partial Thromboplastin
AT	Antithrombin
ATIII	Antithrombin III
ATP	Adenosine triphosphate
Ca^{+2}	Calcium
CAD	Coronary Artery Disease
cAMP	Cyclic Adenosine Monophosphate
CI	Coagulation Index
CO	cardiac output
COX	Cyclooxygenase
CPB	Cardiopulmonary Bypass
CPDA	Citrate Phosphate Dextrose Adenine
DDAVP	*Desmopressin*
DIC	Disseminated Intravascular Coagulation
EACA	*Epsilon Aminocaproic Acid*
FDPs	Fibrin Degradation Products
HCT	Hematocrit
Hgb	Haemoglobin
HIT	Heparin Induced Thrombocytopenia
HIV	Human Immune Deficiency Syndrome
HMW	High Molecular Weight
HSP	Henoch-Schönleinpurpura
HUS	Haemolytic Uremic Syndrome
ICU	Intensive Care Unit
INR	International Normalized Ratio
ISI	International Sensitivity Index
ITP	Idiopathic thrombocytopenic purpura
K	K time

LMWH	Low Molecular Weight Heparin
MA	Maximum Amplitude
min	Minutes
NO	Nitric Oxide
PABD	*Preoperative Autologous Blood Donation*
PFA	Platelet Function Analyzer
PG	Prostaglandins
PLT	Platelets
PO_2	Partial oxygen tension
PT	Prothrombin Time
PT	Prothrombin Time
PvO_2	Mixed Venous Oxygen Pressure
R	Reaction time
RBC	Red Blood Cell
RES	Reticulo-Endothelial System
rFVIIa	*Recombinant Activated Factor VII*
ROTEM	Rotation Thrombelastometry
SLE	Systemic Lupus Erythematosis
TAFI	Thrombin-Activatable-Fibrinolysis-Inhibitor
TEG	Thrombelastography
TF	Tissue factor
TMA	Time of maximum amplitude
TPA	Tissue Plasminogen Activator
t-PA	Tissue Plasminogen Activator
TRALI	Transfusion Related Acute Lung Injury
TTP	Thrombotic Thrombocytopenic Purpura
TxA_2	Thromboxane A_2
U	Unit
UFH	Unfractionated Heparin
VC	Vascular constriction
vWD	Von Willebrand's Disease
vWF	von Willebrand factor

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INTRODUCTION

Surgery is the most common cause of major blood loss, defined as a loss of 20% of total blood volume or more. In particular, cardiovascular procedures are associated with severe bleeding. Patients who have never bled to any significant degree can bleed excessively during cardiac surgery ***(Mannucci and Levi, 2007).***

Conservative strategies to minimize use of RBCs and component therapy are strongly recommended. Appropriate perioperative blood and fluid management are critical to the care of the patient undergoing cardiac surgical procedures ***(Koch and Body, 2011).***

Coagulation and bleeding assume particular importance when surgery is performed on the heart and great vessels using extracorporeal circulation ***(Spiess et al., 2011).***

Adverse effects of allogenic blood transfusion include transmission of infectious diseases, immunosuppression, transfusion related acute lung injury (TRALI), transfusion reactions and graft versus host reaction ***(Mahdy and Webster, 2004)***.

The haematologic management of the cardiac surgical patient entails a complex balance between extreme degrees of anticoagulation and the restoration of normal haemostasis after the procedure. These two opposing processes must be managed carefully and modified with respect to preoperative disease state,

duration of cardiac surgery, use of extra corporeal circulation and the desired haemostatic outcome ***(Shore-Lesserson, 2005).***

Skillful surgery combined with blood saving methods and careful management of blood coagulation will all help to reduce unnecessary blood loss and transfusion requirements ***(Shore-Lesserson, 2005).***

Excessive surgical bleeding causes hypovolaemia, haemodynamic instability, anaemia and reduced oxygen delivery to tissues with a subsequent increase in postoperative morbidity and mortality ***(Mahdy and Webster, 2004).***

Blood transfusion in the past was largely dependent on the use of whole blood, whereas modern practice is based on the concept of specific component therapy.

Blood component therapy optimizes the use of resources by allowing components to be used in different patients. It avoids the potentially harmful effects caused by the transfusion of surplus constituents ***(Spahn and Rossaint, 2005).***

Values of various parameters such as fibrinogen, platelets, hematocrit (Hct), prothrombin time (PT), activated partial thromboplastin time (aPTT) represent trigger points at which relevant blood components should be transfused as RBCs and FFP ***(Spahn and Rossaint, 2005).***

AIM OF THE WORK

Is to highlight the role of anaesthesiologist as regard caring for bleeding and coagulopathy during open heart surgery to provide optimal use of blood component therapy.

PHYSIOLOGY OF HAEMOSTASIS AND FIBRINOLYSIS

The coagulation system is considered by many clinicians to consist just of platelets (PLT) and clotting factors. For some time, however, it has been recognized that many more cellular and molecular components participate in the coagulation process, thereby forming a multifaceted, well-balanced system called haemostasis. Moreover, the coagulation system is not only made for forming clots but is also involved in a variety of defence systems, including tissue repair, defence against micro-organisms, autoimmune processes, arteriosclerosis, tumour growth and metastasis. The main cellular components of the coagulation systems are platelets, endothelial cells, monocytes and erythrocytes, and the main molecular components are the coagulation factors and inhibitors, fibrinolysis factors and inhibitors, adhesive proteins (e.g. von Willebrand factor "vWF"), intercellular proteins, acute-phase proteins, immunoglobulins, calcium ions (Ca^{+2}), phospholipids, prostaglandins (PG) and certain cytokines ***(Bombeli and Spahn, 2004).***

Despite this significant diversification, the coagulation proteins are the core components of the haemostatic system, forming a complex interplay that is still not entirely understood. Whereas the classic separation of the coagulation pathway into the extrinsic pathway (initiated by tissue factor) and intrinsic pathway (initiated by contact activation) still has certain validity, the newer

time-based structuring provides a much more authentic description of the coagulation process ***(Dahlbäck, 2000).***

Haemostasis:

The term haemostasis means prevention of blood loss. Whenever a vessel is severed or ruptured, haemostasis is achieved by several mechanisms:

(1) Vascular constriction (VC).

(2) Formation of a platelet plug.

(3) Formation of a blood clot as a result of blood coagulation.

(4) Fibrous tissue growth into the blood clot to close the hole in the vessel permanently ***(Guyton and Hall, 2006).***

(1) Vascular Constriction:

Immediately after a blood vessel has been cut or ruptured, the trauma to the vessel wall itself causes the smooth muscle in the wall to contract; this instantaneously reduces the flow of blood from the ruptured vessel. The contraction results from:

(1) Local myogenic spasm.

(2) Local autacoid factors from the traumatized tissues and blood platelets.

(3) Nervous reflexes. The nervous reflexes are initiated by pain nerve impulses or other sensory impulses that originate

from the traumatized vessel or nearby tissues. However, even more vasoconstriction probably results from local myogenic contraction of the blood vessels initiated by direct damage to the vascular wall. And, for the smaller vessels, the platelets are responsible for much of the vasoconstriction by releasing a vasoconstrictor substance, thromboxane A2 (TxA_2). The more severely a vessel is traumatized, the greater the degree of vascular spasm. The spasm can last for many minutes or even hours, during which time the processes of platelet plugging and blood coagulation can take place ***(Guyton and Hall, 2006).***

(2) Formation of a Platelet plug:

The vessel wall, with its inner lining of endothelium, is crucial to the maintenance of a patent vasculature. The endothelium contains three thromboregulators: nitric oxide (NO), prostacyclin, and the ectonucleotidase CD39 which together provide a defense against thrombus formation. When the vessel wall is breached or the endothelium is disrupted, collagen and tissue factor become exposed to the flowing blood, thereby initiating formation of a thrombus ***(Bruce and Barbara, 2008).***

Pathways of Platelet Activation:

The idea that two distinct pathways acting in parallel or separately can activate platelets derives from recent studies of thrombus formation. In one of these pathways, exposure of subendothelial collagen initiates platelet activation; in the other,

thrombin generated by tissue factor derived from the vessel wall or present in flowing blood is the initiator ***(Dubois et al., 2006).***

The interactions of platelet glycoprotein VI (a collagen receptor on platelets) with the collagen of the exposed vessel wall and of platelet glycoprotein Ib-V-IX (a cluster of adhesive receptors on platelets) with collagen-bound von Willebrand factor result in adhesion of platelets to the site of injury. The relative importance of platelet glycoproteins VI and Ib-V-IX in the initial tethering of platelets depends on the shear rate at the vessel wall ***(Ruggeri, 2000).***

Tissue factor triggers a second pathway that initiates platelet activation. Platelet activation initiated by this pathway does not require disruption of the endothelium and is independent of vWF and glycoprotein VI Thrombin cleaves protease-activated receptor on the platelet surface, thereby activating PLTs and causing them to release adenosine diphosphate (ADP), serotonin (5HT), and TxA_2. In turn, these agonists activate other PLTs, and in so doing, amplify the signals for thrombus formation ***(Dubois et al., 2007).***

Platelet Thrombus Propagation:

A developing thrombus recruits unstimulated PLTs, and within the thrombus activation occurs only in a subgroup of the recruited PLTs. Others remain loosely associated with the thrombus but do not undergo activation and may ultimately disengage from the thrombus ***(Dubois et al., 2007).***